# Product Design Specification

## Version 1.0

## Visual Aid for Blind People

**Team 7 EEE 2019** (365-team7eee@groups.imperial.ac.uk)

Xia Chen, Umut Ekinci, Lukas Baliunas, Arman Fidanoglu, Alp Atakav, Issa Bqain, Omar Inuwa

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# 1 Performance

For the visual aid for blind people, the key role our device needs to fulfil is its effectiveness in enabling blind people to interpret visual information. Performance can hence be defined as follows:

## 1.1 Effectiveness

Firstly, effectiveness can be defined by its size of contribution to the interpretation and absorption of information through the devices as rated by the blind user, relative to control groups without the devices. The device needs to be able to serve an instrumental role in enabling them to interpret and learn information that are otherwise very difficult to access without vision, or through other existing methods. It should act as an effective learning tool, leading to significant improvements in the test scores of blind students in visual based subjects, and also enable blind users to carry out other visual based tasks e.g. analysis of data, identification of graphical trends, much more quickly and accurately.

## 1.2 Resolution

The images themselves also need to be expressed in as much detail and accuracy as possible, with minimal ambiguity while retaining most properties of the original images (e.g. size, shape, colour, textures) to properly relay the right information across without causing any confusion.

## 1.3 Versatility

The quantity and range of visual information (from mathematical graphs, characters, to colourful charts and images) that can be expressed through our device also needs to be as large as possible, so that it can be used in a wide variety of contexts and cater to a larger range of blind audiences from different age groups and backgrounds. It should also synergize well with other tools used by blind people e.g. text to speech, speech to text, which allows this new technology to be more readily adopted.

## 1.4 Functionality

Technical wise, it also needs to meet basic functional requirements and operate as fast as most modern-day devices, with minimal lag time and excellent synchronization and compatibility with everyday electronic devices and their respective operating systems. It should also be highly sensitive and responsive to inputs from the blind user. Lastly it also needs to be highly customizable and modular to keep up with technological changes, and make it highly scalable for different applications with different requirements for accuracy and sophistication.

# 2 Environment

Several aspects of the products' lifecycle need to be considered. Below are some that have been investigated

## 2.1 Temperature Range

The range is determined by the external housing and stability of the internal electronics. The bottle neck is caused by the electronic reliance hence a suitable temperature environment should be from -10$^{o}$ to 35$^{o}$ which should be easily met during normal use as ambient, domestic temperatures do not exceed this range.

## 2.2 Pressure Range

The operation of the device must work for atmospheric pressures for use by the end user. It does not need to be compliant for higher temperatures as it is not intended to be used in an environment like this.

## 2.3 Humidity

This aspect will only affect the electronics as specified values of internal components (such as capacitors) will change due to the harsh environment. [1] As harsh humid conditions are not common, the device will need to confirm to reliance of approximately maximum 85% (typical summer) to a lower bound of 60% (during a mild winter). [2]

## 2.4 Shock Loading

The device is not designed to be repeatedly exposed to shock loaded environments. It is only to be withstand of a human finger. It will however need to withstand light shocks from drops which has been accounted in the Aesthetics section.

### 2.5 Dust and Dirt particles

The device is not designed to be waterproof however should have a suitable level of IP dust rating as it can endure a large amount of ambient dust during normal use. An IP rating of I (4)(2) or IP42 has been chosen as a specification [3] as it is suitable to prevent small tools or wires (within 1mm diameter) not to freely enter device and also withstand water proof capability for light slashes of water.

### 2.6 Vibration

Device is designed to withstand small amounts of natural vibration. The device may also incorporate an internal vibration system to interact with the user.

### 2.7 End user environment

The end user is determined to be a user that requires visual aid assistance (such as a blind or visually impaired individual).

### 2.8 Likely Degree of abuse

The device is intended to be used in an educational environment. As the device may be exposed to wear and tear due to repeated use, it will need to withstand these as well as small shocks caused by daily use of such devices.

## 3 Life in Service (performance)

In terms of performance, as nearly all electronic devices, we expect that our product remains operational as much as it can. Since our product will contain both hardware and software, we will be able to increase the operational duration of the devices by giving regular system updates.

These devices can have general electronic devices problems like system crash or an issue with the touch of it. However, we have to aim to have at least a one year on full performance since we are in the domain of education.

Life in service is an important aspect of the product design specification since it is related to a lot of important points. For example, the product life span is chosen by considering the duration of the full performance of the device. The performance of the product will be a distinguishing fact on the quality and reliability of the device.

## 4 Maintenance

Given our target audience, it is unlikely that they have the technical expertise to be able to fix or diagnose issues with their device and hence carry out any maintenance on it. Therefore, on a consumer level, it is unlikely that they would be able to carry out any maintenance on the product.

However, this product should have the ability to have any maintenance carried out on it. Since we will not be using any surface mount components, it should be easier to fix any issues with circuit boards or components used such as capacitors or chips that are in dual in line packages. However, this would require knowledge of the product as well as time to diagnose what the problem with it is. Overtime, if the device was to be sold commercially, common technical faults will become known and changes should be made to adjust this such that the product would require less and less maintenance.

## 5 Target Product Cost

The solutions mentioned above range from over seven thousand pounds to free. And thus, in order to properly assess the price of the product we should only look at hardware solutions with similar levels of sophistication and effectiveness in assisting the blind in interpretation, which all cost above 2000 pounds.

With a budget of around 450 pounds, we expect our product, consisting of basic hardware complemented with software, which should operate without any excessively complex or expensive parts, to cost around GBP 500 or less. This is much more affordable than similar high-end hardware solutions listed above, beating out the price range by a large margin.

## 6 Competition

There are several solutions to help the visually impaired with education such as:

*Microsoft narrator, Dragon Naturally Speaking software by Nuance Communications, Refreshable Braille Display, Tiger Braille Embosser Printer, Orcam MyEye 2.0 AI Glasses, Braille Sense U2 Mini Notetaker and Orbit Reader 20 by Royal National Institute for Blind People.*

These solutions range from braille readers, text to speech (TTS) and speech to text (STT). Some of these solutions are free for users of other products by the same company, an example to which is Microsoft Narrator which is available for free for Windows 10 users. There is a significant tradeoff between cost and functionality however, with the more effective and versatile tools such as the Refreshable Braille display being prohibitively expensive (thousands of pounds), whilst the free software only assisting in the interpretation of text and sometimes describing images to a limited degree of accuracy.

Despite the range of existing solutions available, none of the products directly address the difficulty in interpreting 2D images and charts, which neither text to speech nor Braille can directly resolve. On top of that, our research tells us that there are still looming issues associated with education and employment for the visually impaired, with high dropout rates among blind students and high illiteracy rates due to continued lack of access to Braille education. We can therefore infer that there is a lack of product market fit for these technologies in this area. This represents the opportunity for more innovation in the field of graphical interpretation.

## 7 Shipping

**(i)** Considering this product will contain an energy storage device such as lithium ion batteries, there are certain regulations and laws which must be followed which differ for different countries.

**United States**

If the batteries are installed in the device and there aren't more than 2 lithium ion batteries it must have a DOT-approved lithium battery mark, as specified in **49 CFR 173.185(c)(3)(i) and Exhibit 325.2a,** applied to the address side of the mail piece.

**United Kingdom**

You can send lithium batteries in the UK or international post only when they're contained in a device or with a device however not on their own. Additionally, you cannot ship them very close to a metal to avoid overheating and must be contained in a plastic bag. These follow the guidelines set by United Nations and International Air Transport Association (IATA).

Once you have followed the guidelines set in your country, then you must also ensure that you meet the specifications by the country you are sending it to as well if it is sent internationally.

**(ii)** Of course, there are certain weight and dimension requirements which differ by each national postal service and company. Since we are in the UK, we will firstly focus on the Royal Mails specifications:

As we can see here, our product according to out weight and Size research would indicate that we are likely to be placed under "small parcels".

The prices for this would depend on the speed of delivery, which would be determined by the customer and hence they would have to bear the cost for this.

**However, the prices for this would start at GBP 5.10.**

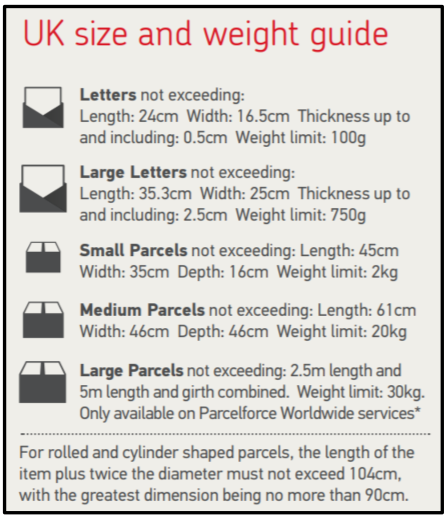


*Figure 1 Quotation from UK's Royal Mail Group [21]*

## 8 Packing

Our device will be an electrical-based product, so it needs to have good packaging against environmental effects to prevent any negative effect on the operation of the device. Since the device can be carried around like a tablet, it has to have a rigid packaging to avoid problems which can be caused at the moment of transportation. In terms of storage, it has to be kept in an environment which has general conditions of working for electrical products. The product must not be packaged such that it could reach temperatures beyond 70 degrees or below -10 degrees; this could cause cracks in the plastic casing.

## 9 Quantity

Quantity is an important aspect to see how many products we need to come up in the first run. Since our project is aiming to aide blind people, we need to find an approximate number of blind people in the world and think of how much of them would like to buy and use our product. Although we are aiming to limit our self with a budget of 450 pounds, we still need to consider the desire of people wanting it.

The World Health Organization estimates that 285 million worldwide in 2012 are visually impaired, with 39 million being blind, indicating significant market demand. 90% of them live in low-income countries with little access to modern technology, signalling a dire need for low-cost alternatives. The market is also only going to get bigger in the future, with the number of people in the UK with sight loss set to increase to 2.7 million by 2030 and double to 4 million by 2050 as the population further ages.

So from the recent search, we can say that we have to do our first product run according to these numbers, which can be approximated by a thousand products.

## 10 Manufacturing Facilities

The following table shows which equipment is needed and the respective properties surrounding it.

| Equipment needed | What for | Where can we access it |
|---|---|---|
| 3D Printers | Printing the casing for it as well as printing smaller pieces such as for one of the solutions with the ”pixels”. | Robotics Lab |
| Soldering equipment | Needed to make the circuit boards for the prototype | Robotics Labs or the EEE labs on the first floor |
| Oscilloscopes , Breadboarding, Bench power supply and Multimeters | Testing and quality assurance | Robotics Lab and EEE labs on the first floor |
| CAD software : Fusion 360, MATLAB, Visual code, Solid works and 2D design. | Designing schematics and Casing | Use the Software hub Provided by imperial to access all the software needed |

# 11 Size

The device must be portable, so the size must be comfortable to use with two hands, as well as, to be easy for the consumer to transport it in a bag. The approximate size of the device is expected to be like a tablet, such as an Apple iPad. So, the size of the product will approximately be 250.6 mm x 174.1 mm x 7.5 mm (height, width, depth).

# 12 Weight

As for point 12 (Size), since the device has to be portable and easy to use with two hands, it cannot weight too much, however, it has to be heavy enough as to not be dropped easily. A good approximation of the weight is a tablet, such as an Apple iPad, which has a weight of 483g. We, thus, aim to have our device weigh under 500g.

# 13 Aesthetics, Appearance and Finish

As mentioned, the device is to be used as an educational aid for visual based content. Consequently, the device will be a main centre console in which the user will directly interact with it through using their fingers (through sense). For this reason, there are several aesthetical properties that need to be specified.

## 13.1 Shape

As discussed in the size specification, the device is designed to be around the same form factor as a portable tablet computer (Apple iPad given as an example). The device will consist of a rectangular, slab-like device with the edges rounded off to give an ergonomic feel. The device must also have a shape that is not too thick to be held easily using two hands as well as to fit in a typical bag.

## 13.2 Form

As our solution is still in the development phase, a form of the device has not been set yet. However, a likely outcome will be that the device will need to be in a form that is most accessible to the end-user. In this case, a form of a 'bar' or 'clamshell' formfactor will need to be considered. These two form-factors will contribute to the usability and portability of the product.

## 13. 3 Texture

The device will need to be ergonomic as well as using materials has textures able to represent information to the end-user. As the device is designed for prevention of daily wear and tear, rubber bumpers could be placed on each edge. The interaction sub-system of the device needs to use a material that is easy to navigate (slide finger across) but not uncomfortable (for instance a material texture of high friction).

# 14 Materials

As the device has a weight restriction and a plethora of other features such as durability and smooth medium for the user to interact with. These factors combined with the difficulty of manufacturing such bespoke systems will need to be taken into consideration.

There are several aspects of the system to take into consideration regarding materials

## 14.1 Battery

The device will feature a rechargeable battery which introduces several challenges. Some aviation industries (such as the US FAA) restrict batteries of Lithium-Ion type depending on their capacity. As a result, we need to not only consider the energy-density of a battery material composition but the safety impact. The external case will also need to house any internal malfunction with the battery system

## 14.2 Outer Casing / External Enclosure

We are restricted by the weight and manufacturing technique for the enclosure. A most suitable option for the casing will be plastic as it is lightweight, offers flexible implantation as well as suiting the safety and performance aspects of the device. A more specific implementation would be to use PLA (polylactic acid) or ABS plastics as they are readily available and are easy to implement using 3D printers (as present in the department). As an example, PLA has a high melting point [i] which is within the operating temperature indicated for the product. [4]

### 14.3 Wear/Tear Bumper Casing

The outer case also needs aspects from which can withstand a drop or wear and tear. For this reason, a material of rubber like texture that can absorb a physical shock needs to be implemented. These include materials such as TPE and TPU, these materials also meet our manufacturing restrictions having 3D printable filaments available for use. [5]

Below are some details of these materials. (Table source given as [5] )

| Filament | Shore A Hardness: | Density: | Print temps: | Chemical Resistance: | Abrasion Resistance: | Shrinkage: |
|---|---|---|---|---|---|---|
| TPE | 85A (very soft) | 1.20g/cm$^3$ | 245-255C HB˜90C | Med | Med-Low | 1.2 – 3.0% |
| TPU | 94A (pretty soft) | 1.21g/cm$^3$ | 245-255C HB˜90C | Med-High | High | 0.8 – 1.8% |

### 14.4 Interactive Front (What the end user interacts with)

This is something the user directly interacts with, typically with using their fingers. Consequently, a material that has low frictional properties as well as managing a good amount of wear and tear is required. A good comparison can be made to mobile devices with a glass or plastic medium to interact with (example being the screen). An example is acrylic glass which is easily manufacturable in our department yet easy to interact with due to its smooth properties.

## 15 Product Life Span

We need to consider two important things. First one is how and how often will we update the software in the device and the second thing is about the guarantee we will give to our customers. For the first point, we can say that we will try to update our software from the feedback we get from our customers because we are trying to aide them so having updates in terms of their desires, it would be a better implementation.

For the second point, normally, electronic devices have 2 years of guarantee from the firms but since our objective is to help blind people, we have to increase this guarantee since it is easier to blind people to damage, we have a problem with the device. In general, we will aim to have a guarantee of 3 years for problems caused by our side and maybe a 1-year guarantee for the issues that blind people had when they are using it.

Normal companies don't give a guarantee for people-based damages but since we are in a more likely business, we need to give it.

## 16 Standards and Specifications

Our device will include a rechargeable battery, thus specific standards need to be met:

IEC 62133-2:2017 – specifications, requirements and for safe operation of portable rechargeable batteries in electronic devices.

## 17 Ergonomics

The device needs to be built around blind people's perception of the world, in order to suit their needs and make it as easy to use and convenient for them as possible, optimizing usage experience. The design needs to be thoroughly researched and conceived based on feedback from blind organizations and people, with all potential shortcomings (e.g. incorrect view of images from different orientations) accounted for. Important features also need to be properly labelled and marked out on the device in a way that is obvious to the blind user.

It should preferably look simple and elegant, without any excessive complexity beyond its basic functions, and can be easily set up and operated independently by blind people or the general public without prior training. In order to avoid causing any additional hindrances to their daily lives, it should also be handheld and portable, without any need for extra accessories.

## 18 Customer

The target users would be visually impaired individuals across different backgrounds and age groups ranging from students who are learning visual based subjects in school to adults/elderly trying to find employment and live independently.

According to our statistics, most of the visually impaired population are either unemployed or struggling to make ends meet. The target user would therefore not have a high level of disposable income or assistance. Our product hence also needs to prioritise cost and ease of use besides effectiveness in order to directly address most of our audience.

## 19 Quality and Reliability

This product will be used in many different settings ranging from education to jobs. Therefore, it could be used by students, volunteers, professionals and elderly, hence:

- ⇒ It must hold enough charge to last a school/working day.
- ⇒ It must not be easily prone to getting damaged e.g falling of a table.
- ⇒ Easily integrated within educational environment to assist learning.

Since we are aiding the education of the blind, our users will be placing their trust in our product and hence it must work seamlessly and therefore we must ensure the product has a long lifespan and does not have any discontinuous behaviour.

## 20 Shelf Life (Storage)

This device is a non-perishable good and therefore it should have a relatively long shelf life. The shelf life of electronic products is significantly affected by aluminium electrolytic capacitors also known as E capacitors. Due to the conditions of temperature and humidity in which they are stored, this could result in the drying out of the electrolytic capacitor and to an irreversible loss of capacity.

There are many other factors which effect this as well including the effects of climate fluctuations and intensity, the quality of the capacitor seals at the lower end of the cup which are determined by the stability or porosity of the rubber compounds used in the seal, formation effects in capacitors and the chemical composition of the capacitor's electrolytes.

Hence it would be difficult to estimate a time for the shelf life if electrolytic capacitors are used however, chips when made are usually intended to be used indefinitely.

## 21 Processes

There are many steps that must be taken to ensure that this prototype is delivered within the limited timeframe. The main components that need to be designed tested and made are the schematics, Logical function of the device implemented through code and 3D printing a casing to protect the product. As we have shown above, the resources needed to realise all of this are readily available to us and we have listed a period to make sure we complete all tasks by a certain deadline to finish in time.

## 22 Time-scale

The time scale for the project is reflected in the table below:

| Start | Task |
|---|---|
| 1/10/19 | Group Formation |
| 9/10/19 | Work on the proposal of the three problems |
| 20/10/19 | Work on feasibility study |
| 31/10/19 | Response to Feasibility study |
| 7/11/19 | Work on Product Design Specification |
| 17/11/19 | Investigate solutions |
| 3/12/19 | Testing: |
| 13/2/20 | Prep for Poster presentation and Demo |
| 6/3/20 | Work on Video and Final Report |

## 23 Testing

Testing of the product would be done within the project time frame, to ensure that the product is able to meet the needs of the user.

## 24 Safety

The team must consider that the product should be made in a manner that minimizes and if possible, eliminate the risk injury whilst encountering a malfunction of the product. Furthermore, the product must not have any sharp edges that might cause harm to the user. And appropriate braille instructions must be included, and all potential risk associated with the battery or electrical system.

## 25 Company Constraints

When designing the educational aid system, the team will be constrained to the facilities available for use, such as: Robotics Lab at Imperial EEE and Imperial College Advanced Hackspace. Financially, we are restricted to a development budget of GBP 450.

## 26 Market Constraints

The current market size is constrained to the local market, England and wales, due to the development stage of the project and the lack of manufacturing expertise and international trade experience. Based on a report by W.H.O it is estimated that 0.05 per cent of children have a visual impairment worldwide.

The population of England and wales is 3.1million and of that 21% are under 18. Based on that a good estimate of the market size would be 326 individuals. However, there is an estimated of 2 million people with sight loss in the UK and of this number 360,000 are registered with the NHS. As a result, there would be potentially a larger target audience as the product reach goes beyond the current target audience and market.

## 27 Patents, Literature and Product Data

Patents along with other information detailing designs similar to ours will be thoroughly researched and known in advance to avoid any patent clashes. This also includes existing patents without any prototypes built or actual products on the market. The scope should also go beyond blind applications, to other devices with similar operating mechanism as our devices.

## 28 Political and Social Implications

The product has a positive social impact, likely leading to increased literacy and employment rates and is likely to be well received by the population. It does not have any for seeable political implications.

## 29 Legal

The possible legal aspect might be potential patent infringement with current products. However, since the product is development for non-commercial use now, under patent law we would not have to worry about any legal consequence of patent infringement. If in future the product is to be monetized and the product infringes on existing patents, the team plans to work with the patent owners to bring the product to market without any legal consequences.

## 30 Installation

The installation of the device is broken into 2 main parts. The end user is not required to do any extensive installation – this will be carried out at the manufacturing stage.

⇒ **Manufacturing Stage:** The device is intended to use an enclosure to house any electronic components. Fixtures such as screws, bearings and binding glue may be integrated when manufacturing the device. An installation of a battery will be required at the factory.

⇒ **End consumer:** The end user is only required to initially charge the device and set it up initially by inserting a software package to load the different media that needs to be represented visually. Although not a requirement, a battery may need to be manually inserted into the device by the end user.

The end user must also plug the system into a DC power supply to charge the device for first use and subsequent uses.

## 31 Documentation

All required user documentation must be made for the visually impaired accompanied by worded instructions for non-visually impaired individuals, in the event an individual without visual impairment e.g. volunteer needs to read it.

## 32 Disposal

Circuits Contain copper which can be recycled however the FR4 epoxy glass laminate which makes up the bulk of the bare PCB cannot be recycled back to its constituents. For customers, recycling the actual PCB and/or reusing components although useful, is impractical and requires technical information and hence often PCBs are sold at very cheap rates to plants which recycle the small amount of precious metals in them and other material is scraped. PCBs must be consolidated into reasonable bulk amounts 50 to 100kg perhaps to make recycling economical, otherwise, freight costs will exceed the scrap value of the metal recovered.

For example, at the Newbury electronics plant, they recycle used drills, aluminium entry board, MDF backing board, scrap laminate, spent etchant, used chemicals, scrap tin, scrap copper, scrap steel, scrap equipment, and cardboard. Anything not recyclable is incinerated to produce electricity and any wastewater from the manufacturing process is filtered before discharge.

Most common 3D printers use plastics such as ABS (others include PLA and ASA) depending on weather they use FFF or FDM technologies. These plastics can be recycled when the plastic is sent to a recycling centre, it gets washed, sorted, shredded, and then melted into small pellets, which are then used as raw material for the manufacturing of new products.

# References

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